ENGINEERING CASE LIBRARY

ECL 126

Plastic Pipe Saddle Design

Early in 1965 sales representatives of Smith Blair Corporation of South San Francisco began to report that there was excellent market potential for an improved "saddle" for plastic pipes.

Pipe saddles are functionally similar to T-joints; they are used extensively in piping networks for branching off from the main line. Exhibit 1 shows an example of such an application in an irrigation system where they are used for connecting a riser to a main line. These saddles, unlike T-joints, do not require cutting off of the main line at branching locations, and as a result are easier to mount. Moreover, since they can be mounted after the main line has been fully laid out, their use simplifies the installation of piping networks.*

Smith-Blair, Inc., concentrating mainly in the field of water works equipment and supplies, has, over the years, accumulated considerable experience in the design and manufacture of pipe fittings such as clamps, couplings, and saddles for the various types of pipe.

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*In fact it is possible to mount them on existing networks without interrupting the flow in the main line.

Prepared in the Design Division, Department of Mechanical Engineering, by Mr. Prem Garg under the direction of Professor H. O. Fuchs with financial support from the National Science Foundation. The cooperation of Mr. Frank Turner and Mr. W. R. Reinbacher is gratefully acknowledged.

Rapid advances in the field of plastics during the last decade or so have resulted in the increasing popularity of plastic pipes for municipal, irrigation, gas, and industrial uses. Reduction in transportation costs, better corrosion resistance, lower pressure head losses, flexibility, and easy handling in the field have been some of the factors contributing to the popularity of plastic pipes. However, as the salesmen pointed out in their reports, there was a need for inexpensive, easily mounted, reliable fittings. For branching off there were quite a few saddles available on the market; none of them, however, was satisfactory to plastic pipe users. The existing saddles, broadly speaking, were of two types: plastic saddles welded to the plastic pipe by heat or solvent, and metallic saddles with two halves bolted together around the pipe. The first type were cumbersome to install and often produced joints of unreliable quality. Metallic saddles on the other hand because of surface irregularities and sharp corners, tended to notch the pipe, damaging the pipe line itself. Also vastly different thermal expansion for metals and plastics made the joints very sensitive to environmental temperature variations. The reports had stressed that a product without the above troubles would enjoy a good market for itself and would possibly help the sale of the other products as well by plugging a gap in the company's existing line of products.

Smith-Blair, Inc. was being encouraged to go ahead with such a product from another quarter as well -- by Mr. Reinbacher of Jupiter Engineering. Jupiter Engineering, a young Menlo Park, California, organization,worked on the design and production of plastic molded products for a diverse group of clients. Mr. Reinbacher, Jupiter's President, said during a number of informal talks with Smith-Blair personnel that a suitable pipe saddle would be economically and technically feasible. Also he felt that Jupiter Engineering, with its experience in the design of new products in plastics would be able to contribute significantly towards such a project.

In September 1966, Mr. Frank Turner, Manager for Development of New Products, was instructed by Mr. Telford L. Smith, President of Smith-Blair, Inc. to go ahead with the development of a suitable plastic pipe saddle.

Mr. Turner believes in "getting intimate" with his design problems before he tries to solve them. "This," he says, "does not take much time but does avoid frequent embarassments which follow when you start working without knowing clearly what you are aiming at." Based on his experience with the fittings for metallic pipes, he started listing various factors which he thought could be important in the project. Accordingly, he prepared a memorandum to management asking about the pertinent information (Exhibit 3).

Early in the project Mr. Turner recognised that metallic saddles were inherently incompatible with plastic pipes; an appropriate solution would require devising some improved way of mounting the plastic saddles rather than trying to improve the quality of the metallic saddles. Though Mr. Turner had worked with plastics once before (with his previous employers), he felt he needed to know more about plastics before attempting this design. So he started collecting some basic information about design considerations with plastics and about their general behavior. Exhibit 2 shows an example of his findings.

Meanwhile, Mr. Turner had also been thinking of possible designs. Since the main problem with the existing saddles arose during installation, Mr. Turner was anxious to avoid anything which required welding in the field. Mechanical joints seemed to be the logical way of approach. With this in mind he sketched a number of possible designs. Broadly speaking, they fell into two categories: one involved fastening of two halves by bolts, as is done for metallic pipes, and the other incorporated a band tightened around the two saddle halves (Exhibit 4A and 4B). An O-ring seated in a groove in the top half of the saddle provided the necessary sealing. A stainless steel reinforcing cap at the boss was pressfitted to check against overstressing and cracking of the boss due to overtightening of the connecting piece. Since theoretical analysis of these designs appeared too complicated and crude to Mr. Turner, he gave the promising sketches to the pattern maker working under him, and asked him to construct models which could be used for testing and evaluation.

"I discussed some of my initial ideas with Mr. Reinbacher and we felt that the band type saddles would be preferable to those using bolts for several reasons:

1. The bolted joints loaded the saddle in flexure and consequently there would be cold flow in tension-loaded zones, resulting in the loosening of the joint. On the other hand a band around the saddle would give a uniform radial compression which would be a fail safe design against the cold flow.

2. Bolt type saddles with their vise-like action would tend to deform the pipe, as opposed to the band type which, with their uniform compression all along the pipe would tend to reinforce it.

3. Band type saddles with their worm screws would be vibration free.

Mr. Reinbacher also felt that it would be somewhat harder and more expensive tooling wise to mold the bolt type since they would require molding internal threads, a difficult thing to do in plastics with their high shrinkage.

"Early tests which we ran for some of the models tended to support our views. As the project progressed we found that the band type had another advantage as well: the bolt type had to be tightened with a wrench which meant considerable earth digging during installation to allow room for turning the wrench. The band type, on the other hand, could be installed with just a screw driver. This I thought could result in substantial saving during installation."

With this background Mr. Turner decided to concentrate on the band type saddles only and started improving his preliminary designs. Some of the prominent changes he made are described below:

1. The stainless steel bands which were placed coaxially to the pipe in the early designs were shifted to diagonally opposed grooves with their axes making angles of 15°* with the pipe axis (Exhibit 4C). This resulted in increased thickness at the base of the boss and thus made it stronger against pressure leakage.

*This inclination was subsequently changed to 10° to keep uniformity for different sizes.

Also it resulted in a "more favorable stress distribution around the O-ring". As a result some 30% increase in pressure rating was observed during tests.

2. The mating line of the two halves was modified to allow for thermal expansion and contraction (Exhibit 4D). For easy installation the bottom half was made to be snap fit on the pipe and for axial alignment a shoulder was provided on the parting line. Also for proper location of the saddle vis-a-vis the hole in the pipe a positioning neck was provided at the base of the boss which fitted into the hole drilled in the pipe. (The neck could be machined off, if desired; for "wet mounting", i.e. mounting while water is running in the main line, it was necessary to remove the neck.)

All along Mr. Turner had been thinking about a suitable material from which to make the saddle body. Most of the existing pipes were either in PVC or ABS, both of which seemed to be obvious candidates for the saddle. However after extensive testing with numerous materials and after consultation with Mr. Reinbacher, it was decided to use high impact polypropylene. Exhibit 5 explains the choice of polypropylene.

Exhibit 6 shows a sketch of the saddle as it appeared in the final stages of development.

Once Mr. Turner had finalized the design, he contacted Mr. Reinbacher for design of the tooling to be used for molding. Injection molding is one of the most economical processes for mass producing plastic parts. Melted or plasticized thermoplastic material is injected into a cooled mold where it chills enough to be removed in a solid shape, duplicating the cavity of the mold. To get high production rates, the mold generally is made up of a number of similar or dissimilar cavities. Usually the part and the mold can be designed so as to get a finished product straightaway. However due to the high shrinkage of plastics it requires quite a bit of experience and luck to get the finished product within specified tolerances from the first mold. Often modifications have to be made in the mold to get the desired shape. "At Jupiter, rather than wasting too much time in perfecting the first mold, we work on

the assumption that something will go wrong and hence we try to design the mold so that we can make changes subsequently. Removing some more metal from the mold at later stages is much easier than plugging in unwanted gaps, so wherever we are in doubt we try to remove only the metal that we are certain will have to be removed," explained Mr. Reinbacher about the design philosophy of his corporation.

Tooling, which usually is pretty expensive even for simple products, is generally paid for by Jupiter's clients. "This works better for both parties. Our clients are able to get their products at lower costs and we do not have to risk our capital in expensive tooling," said Mr. Reinbacher. As the tooling for the saddles was going to ge quite expensive (a single cavity costs around $4,000) it was suggested by Mr. Reinbacher that to start with they could procure the tooling for only one size. He felt that the experience gained from its design would be helpful in subsequent tooling design. Also, this way Smith-Blair, Inc. would be able to check the quality of the proposed product without risking too much money and would be able to make modifications, if need be.

By April 1967 Jupiter Engineering was able to deliver to Smith- Blair, Inc. a prototype batch of 40 saddles for testing and evaluation. This batch was subjected to extensive testing. (See Exhibit 7 for one of the test rigs and Exhibit 8 for a specimen test report.) It was found that while the design was basically sound, it did not come up to their specifications as regards dimensions and strength. In a meeting with Jupiter Engineering the various problems related to tooling, molding, gating and shrinkage, etc. were discussed and some modifications were agreed to. (See Exhibit 9 for modifications.) The subsequent product was found to be satisfactory and it was decided to go ahead with the other sizes.

Mr. Reinbacher estimated that if Smith-Blair, Inc. were to go for individual cavities for all the sizes (there were some 40 different combinations as a result of various pipe and boss sizes, as well as different pipe standards), they would have to invest about 200,000 dollars for the tooling. The management of Smith-Blair was, for obvious

reasons, reluctant to invest such a large sum on a product with still uncertain market status. However, at the same time it was felt that a complete line of products was necessary to effectively penetrate the market. Obviously some means had to be found to reduce the tooling cost to a reasonable amount. Mr. Reinbacher suggested two solutions:

1. Get the tooling for only a few popular sizes and use reducers to accomodate different sized taps with the same boss size.

2. Use a threaded insert to get the required threads inside the boss. The same insert could be used with all the saddles and reducers having that size.

Both of these suggestions were accepted and a nylon reducer was designed for the purpose. As a result the tooling costs were reduced to about 35,000 dollars. With 8 basic saddle sizes and 5 different reducers they were able to get 31 different combinations (see Exhibit 10). By April 1968 all the different sizes were in production.

"At Smith-Blair, Inc. we are very conscious of our reputation with our customers. We did not want to take any chance with the quality of the new product. I thoroughly investigated the various possible sources of trouble and drew an extensive quality check-up plan (see Exhibit 11). Also for the smooth progress of the project with our production department I chalked out detailed assembly instructions as well as a complete plan for the procurement of different components from the various vendors (see Exhibits 12, 13).

"To avoid any infringement of our design by our competitors, we instigated a patent search and then we applied for a patent and expect to get one that is pretty exclusive.

"Finally, I arranged for an informal get together with our sales personnel to acquaint them with the salient features of the product. I also informed them about the quality of our competitors' products, some of which I had tested for comparison (see Exhibit 14).

So far the product has been doing as expected. People at Smith-Blair, Inc. are very enthusiastic about it. Sales to-date show the product as being well accepted thoughout the country and indicate a steadily increasing market.

List of Exhibits

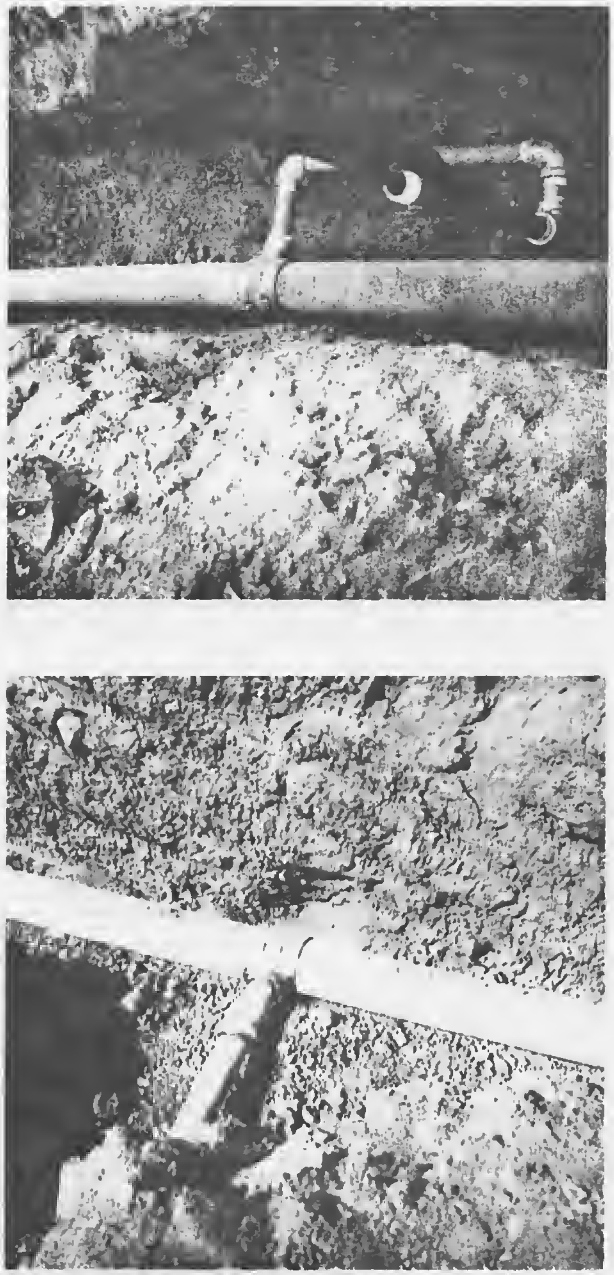


EXHIBIT 1 VIEWS OF A PIPE SADDLE IN USE

DESIGN FACTORS FOR THERMAL PLASTICS PARTS

Design for minimum wall thickness to satisfy structural requirements - saves material - increases production rate because of faster transfer of heat from molten polymer to cooler mold surfaces.

Design for uniform wall thickness to eliminate distortion, internal stresses and cracking.

When different wall sections required - blend gradually.

Width of base of rib should be less than thickness of wall being joined to.

Taper ribs.

Unsupported ribs no higher than 3 times their wall thickness.

Height of boss not more than 2 times its diameter.

Edge distance for hole = hole diameter minimum.

Vertical step of 1/64" minimum at open end of holes.

Coarse threads easier to mold than fine threads, avoid threads finer than 32 per inch.

1/32" minimum depth shoulder before start of threads.

Tolerances for parts should be given in inches per inch, not in fixed value.

Multi-cavity molds increase tolerances.

Sharp corners greatest contributors to part failure.

Minimum fillet $\frac{R}{t}$ = 0.6 where R=Radius and t= section thickness.

Minimum fillet or corner Radius = 0.020.

Best radius at least equal to wall thickness.

Avoid undercuts where possible (can under-cut some materials up to 40 mils).

Material shrinks away from mold, design draft angles accordingly.

Minimum draft angles vary with materials - $\frac{1}{4}^{\circ}$ to 2° common.

EXHIBIT 2 LIST OF DESIGN FACTORS FOR THERMOPLASTIC PARTS

Frank E. Turner
Nov. 22, 1966

MEMORANDUM

TO: Hardy M. Smith
cc: Telford L. Smith
Luther L. Smith

FROM: Frank E. Turner

DATE: September 30, 1966

SUBJECT: Saddles For Plastic Pipe (Project commenced 9/23/66)

COPY

The information received to date concerning requirements for design of saddles for use on plastic pipe has mostly been by word of mouth from several sources. The information I have as of this date is generally as follows:

a. The need for 2, 3 and 4 inch Saddles, each with 1" and 3/4" I.P. bosses, per Hardy Smith.

b. Handwritten list from Luther Smith indicating

2"	with 1" outlet	yearly sales	10,000
3"	"	"	8,000
4"	"	"	12,000
6"	"	"	6,000

c. Someone mentioned the possible need for 1/2" bosses.

At the present time I have a number of saddle designs in mind, some of all Plastic and others a combination of metal and plastic. I have a tentative appointment set up with a plastic molding company the early part of next week for preliminary discussion of various designs. In order to discuss realistically and to benefit from this meeting, answers and/or confirmation of the following is needed:

a. Over-all program (or long term program)

1. Will we eventually want saddles for 1½", 2", 2½", 3", 4" and 6" pipe?

2. Maximum boss sizes for each of the above?

3. Bosses for I.P. tap only or will there be a need for C.C. taps?

4. Are we concerned with sizes 2, 3 and 4 inch each with 1" and 3/4" I.P. bosses - only these at this time?

5. If "yes", would there be a future requirement for a boss larger than 1" or smaller than 3/4"?

MEMO to H. M. Smith
T. L. Smith
L. L. Smith

Answers to the foregoing would be helpful in order to come up with the least expensive mold design, where interchangeable parts in mold can be used, etc.

b. Quantities

1. Need realistic quantities for each different saddle, for example:

   quantity of 4" x 1" I.P.
   quantity of 4" x 3/4" I.P.
   etc.

   Quantities directly affect mold and part cost.
   For large quantity, molding may be completely automatic.
   For smaller quantity, molding may be semi-automatic.
   Number of parts molded per hour affects part cost, etc.

c. Material of Saddle

1. Assuming major portion of saddle is made of "Polypropylene" (Plastic), will this type of plastic material be acceptable and/or endorsed by the manufacturers of Plastic Pipe for use on their pipe lines, since most pipe is of PVC or ABS?

   The type of Plastic used affects mold cost, mold design and part cost. Assuming molds are made for Polypropylene - to run PVC in same mold at later date cannot be done.

2. For hardware portions of saddles, are the following acceptable?

   Stainless steel______, "Corten" or equal______, (uncoated)

   Galvanized steel______, Brass______

d. Color of Saddle

1. Assuming saddle of plastic -

   How important is color?

   Is "blue" desired?

   Would color other than blue, or no color, be acceptable if result would be lower part cost?

COPY

EXHIBIT 3

MEMO to H. M. Smith
T. L. Smith
L. L. Smith

e. Cost

1. For each size saddle made, what would our maximum allowable cost to manufacture be (factory net)?

f. Pipe

1. What type of pipe will saddles be used on - manufactures, materials, and pressure ratings?

g. General

1. Rate saddle at 160 psi?

2. Rate saddle at greater pressure?

3. Design saddle for greater pressure? If so, how much?

4. Operating conditions -

Static?

Subject to vibration?

Buried?

Exposed to sunlight?

Minimum and maximum temperature subjected to?

Subjected to water, oils, solvents and/or what chemicals?

5. Design features in addition to non-corrosive, wide full encirclement support, leak-proof, fast easy installation, rigidity, simplicity and suitable elastic properties of sealing member to follow creep or cold flow of pipe?

6. Depending on the tap sizes we end up with on these saddle bosses, we should obtain for each a new "Corpstop" or any other connecting member that will be screwed into the plastic saddle boss in field use. These will b used to evaluate fit and strength of Plastic boss.

Frank E. Turner

FET/jm

COPY

EXHIBIT 3

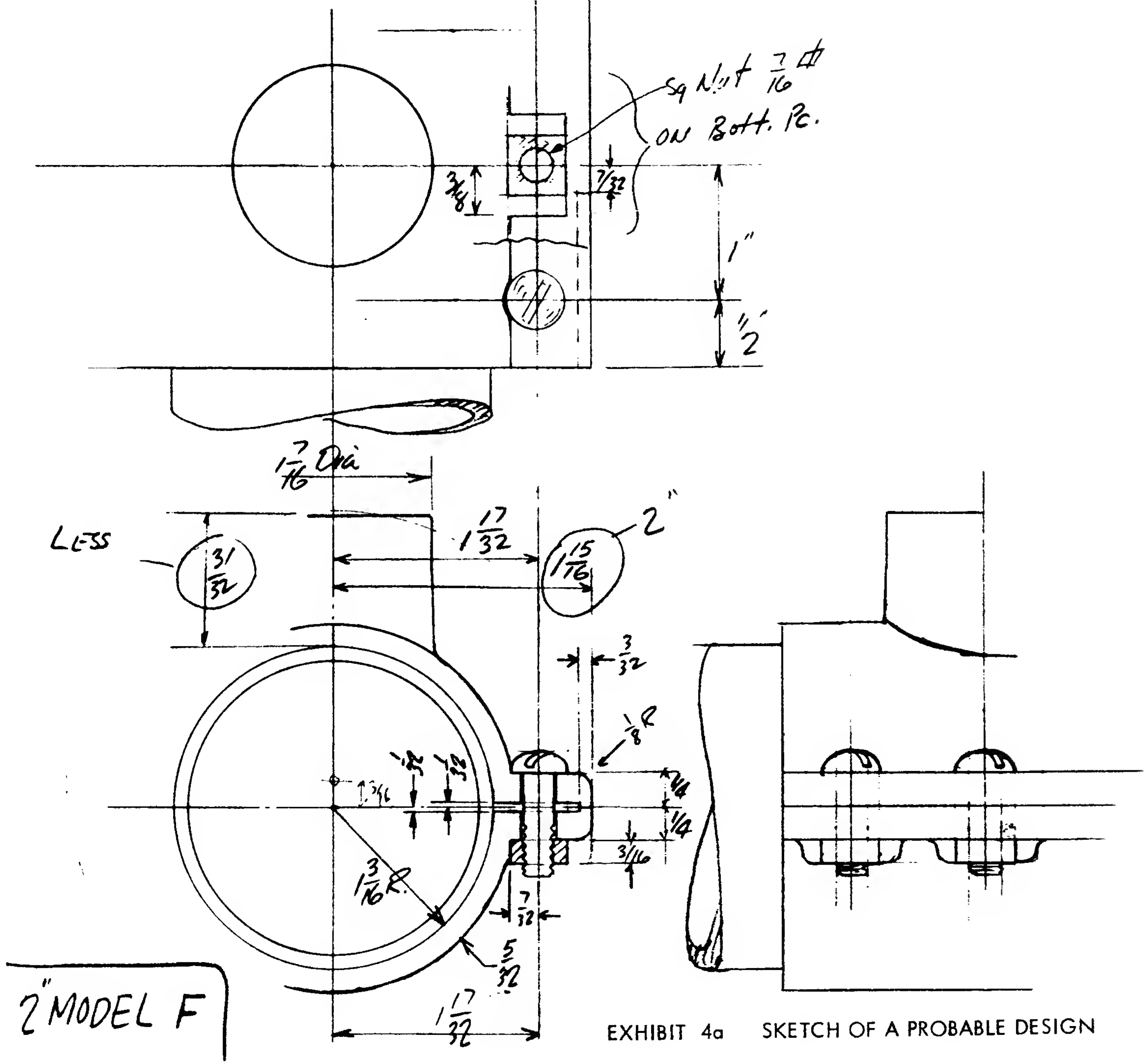
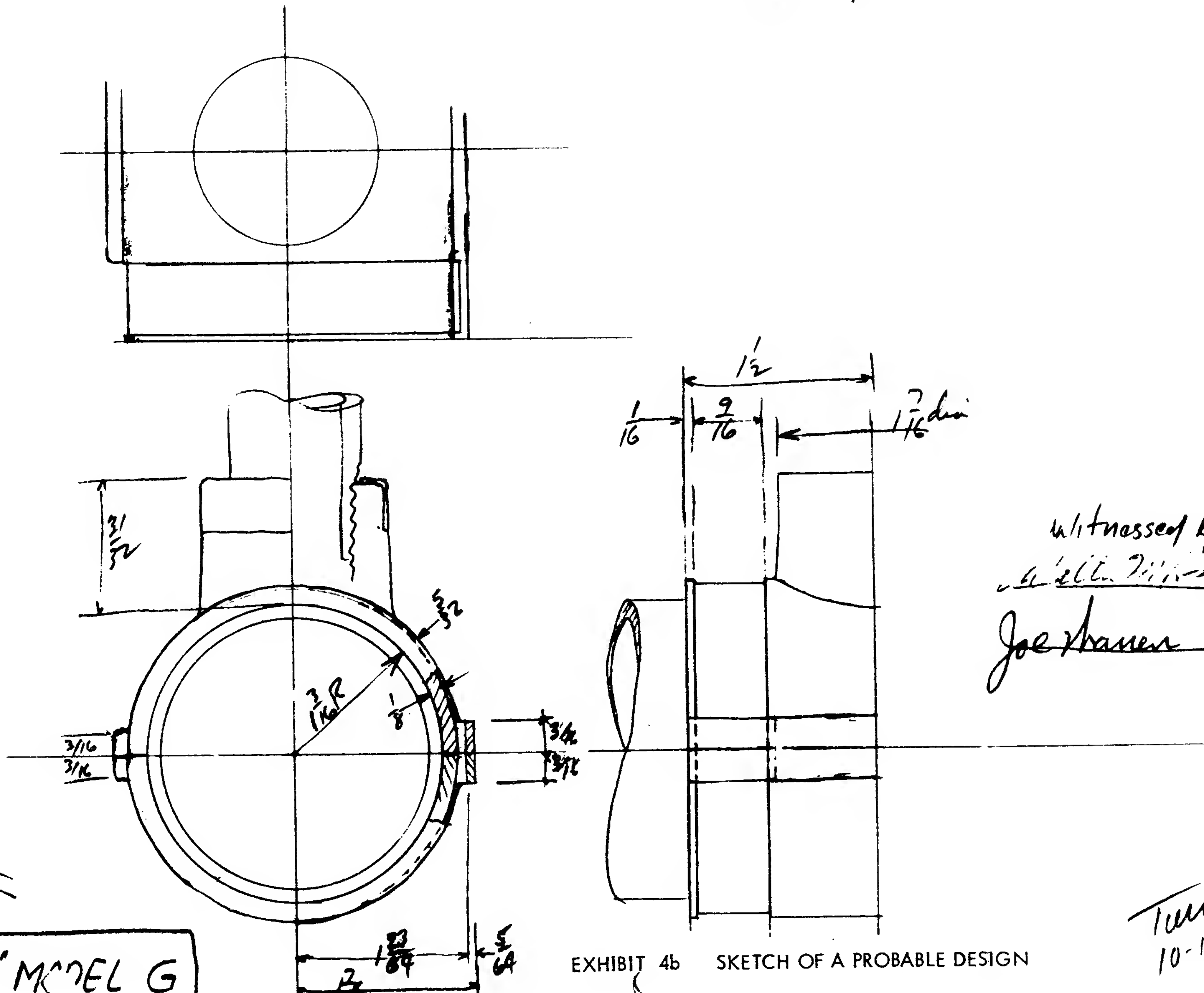


EXHIBIT 4a SKETCH OF A PROBABLE DESIGN

ECL 126

Turner 10-18-66

Mold loop to thread Clamp



witnessed by

[illegible] 10/18/66

Joe [illegible] 10-18-66

ECL 126

Turner
10-18-66

2" MODEL G

16

EXHIBIT 4b SKETCH OF A PROBABLE DESIGN

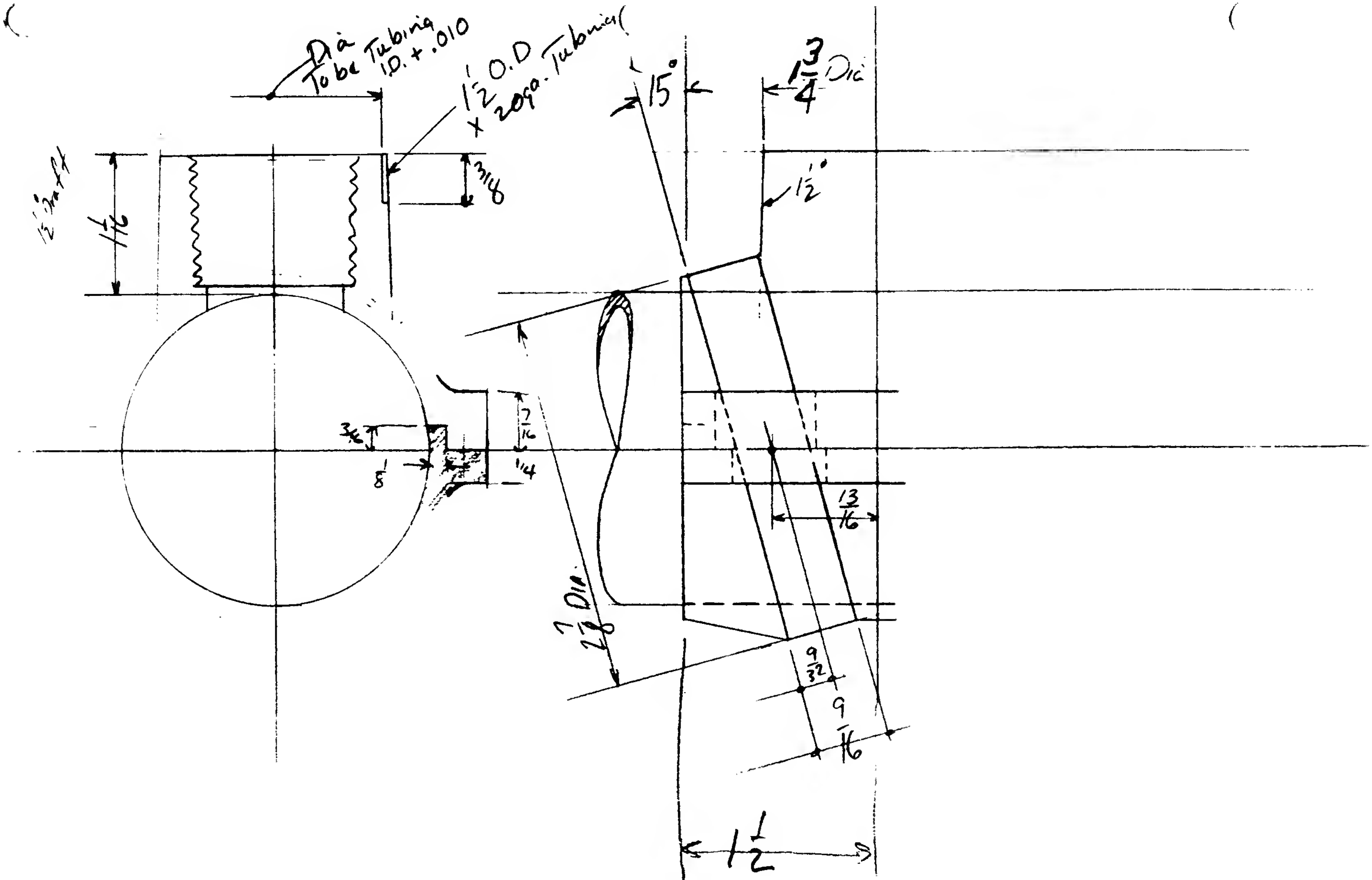
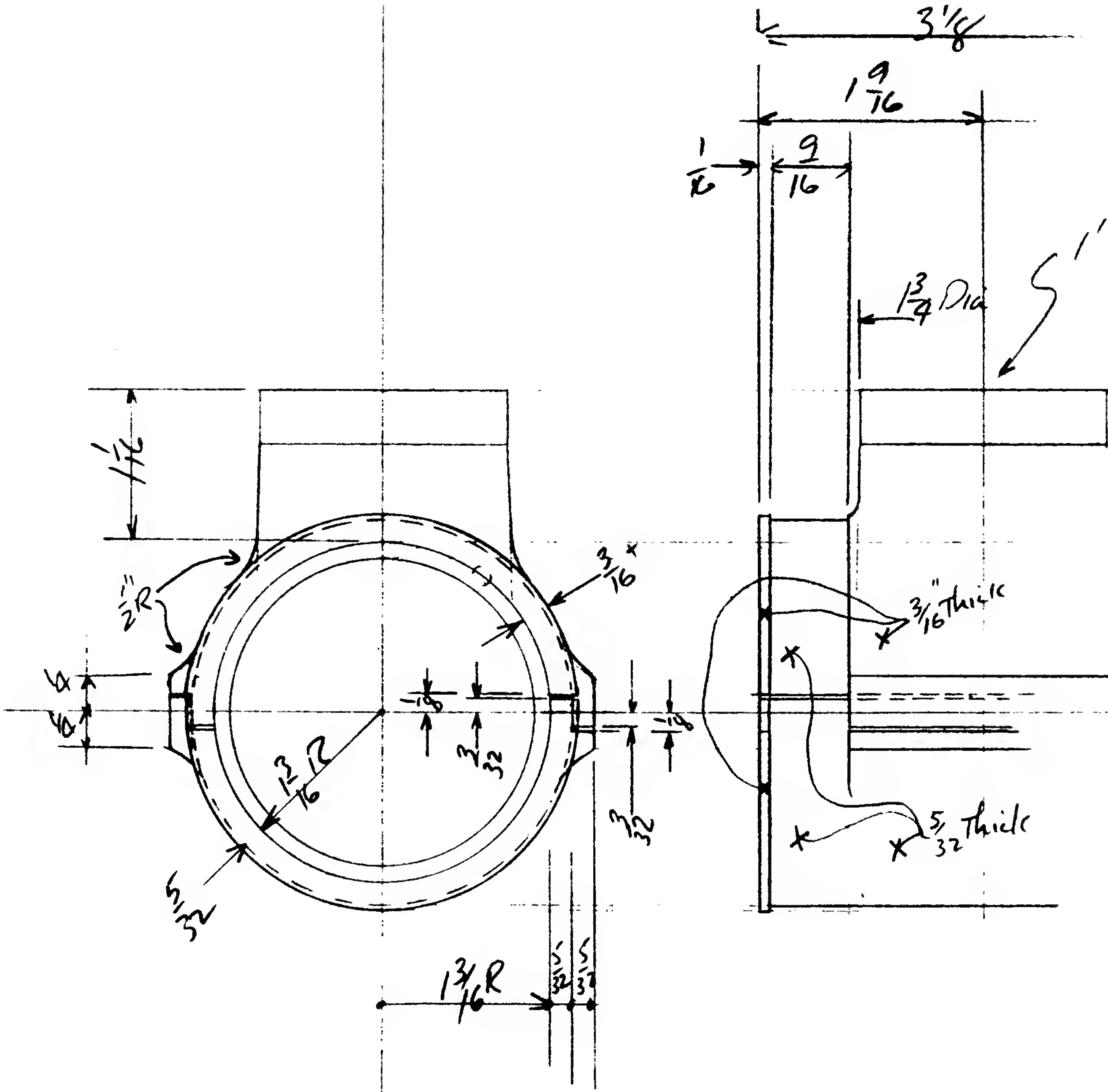


EXHIBIT 4c SKETCH OF AN IMPROVED DESIGN

2" MODEL J

Turner
11-10-66

Witnessed by
[illegible] 11/10/66
Joe Hansen 11-10-66



witnessed by

11-21-66

Joe [illegible] 11-21-66

Turner
11-21-66

2" MODEL M

EXHIBIT 4d SKETCH OF AN IMPROVED DESIGN

ECL 126

cc: Telford L. Smith

File
This letter was requested By Luther Smith on 5-31-67

ECL 126

Luther L. Smith   Frank E. Turner   June 2, 1967

Material Selection - Type 342 Plastic Saddle

X

COPY

Occasionally we are asked the question "Why did you choose to manufacture your saddles of this specific material?"

As you know, we have been working with this material for approximately nine months. After months of evaluating and testing a good number of saddle designs, sizes and materials,it was determined that for our application polypropylene, in general, appeared to be the most suitable at this time. Since the load application and other design criteria for satisfactory saddle performance differs immensely from normal PVC, ABS and other type plastic pipe cylinder design criteria, it was felt necessary to choose this material with its broad scope of properties. With this material our saddle is compatable with most all plastic piping systems, including PVC, ABS, PE, etc.

In working with other materials we experienced many problems, such as leakage at the threads, cracking in saddle body - occurring after being under constant hydrostatic pressure for long periods of time, brittleness at lower temperatures, tendencies to reshape pipe, etc.

With polypropylene in mind we proceeded to manufacture a production type of mold to produce the 2 inch saddle size. Upon completion of molds we were able to obtain sample saddles in various grades of polypropylene and in some other materials. After months of study it was proven that the most suitable material for our first run of saddles would be "Shell Polypropylene V-526 High Impact - Medium Flow Copolymer" (specifications attached).

Of the many reasons for selecting this material, some are as follows:

It has been test proven.

It is compatable with pipe systems of other materials.

It exhibits the necessary flexure and strength properties.

Its resilience - particularly in sealing at threads.

EXHIBIT 5   NOTES ON MATERIAL SELECTION

Its resistance to stress cracking.

Its chemical resistance.

It is an F.D.A. approved material.

It allows the necessary molding cycle to produce parts at a desirable cost.

Similar fittings of the same material by other reputable manufacturers are currently in use and performing satisfactorily.

As we continue to design and develop new sizes and type saddles the material will be evaluated in parallel.

FET:jm
encl.

C O P Y

EXHIBIT 5

SMITH BLAIR

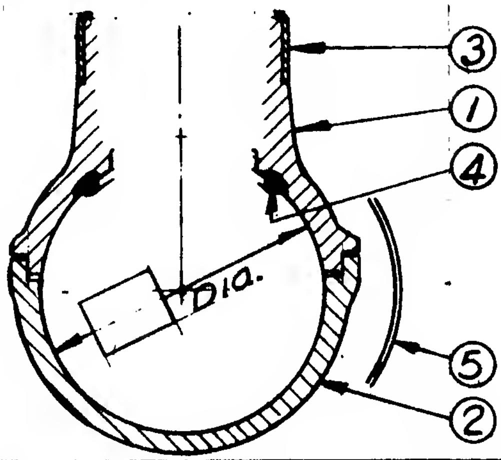
SMITH-BLAIR, INC.
SOUTH SAN FRANCISCO, CALIF.

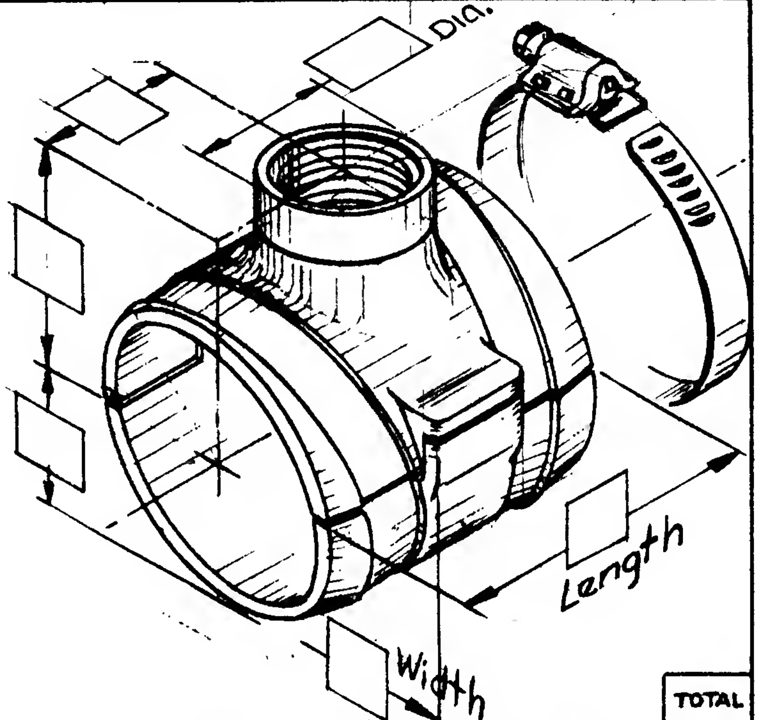
MATERIAL LIST

CODE		SHEET	1
L	ECL 126	OF	1

DATE:	E. TURNER	PLASTIC SADDLE	CATALOG NO. 342-	ADDRESS NO.	ST'D
VOIDS:					SP'L

SIZE: I.P. C.C.
THREAD MOLDED
THREAD MACHINED
WITH NECK
WITHOUT NECK





ITEM	QT'Y	PART NO.	DESCRIPTION	MATERIAL	FINISH	DRAWING NO.	TOTAL ITEM WT.
1	1		Body-Top	PP-Shell V-526 Color A4B47D Blue	As Molded	SF	
2	1		Body-Bottom	Ditto	Ditto	SF	
3	1		Reinforcing Cap Hole Dia.	Stainless Steel 302/304		SF	
4	1		O-Ring- Parker	Nitrile (Buna N) Durometer		—	
5	2		Worm Drive Clamp Breeze Corp. No QS200-M H	Stainless Steel 302 and 305		—	

REMARKS:
Press fit item 3 onto item 1
Cement item 4 to item 1

EXHIBIT 6 A SKETCH OF THE SADDLE IN FINAL STAGES OF DEVELOPMENT

FILE NO. 7-

REV'D UNIT WT.

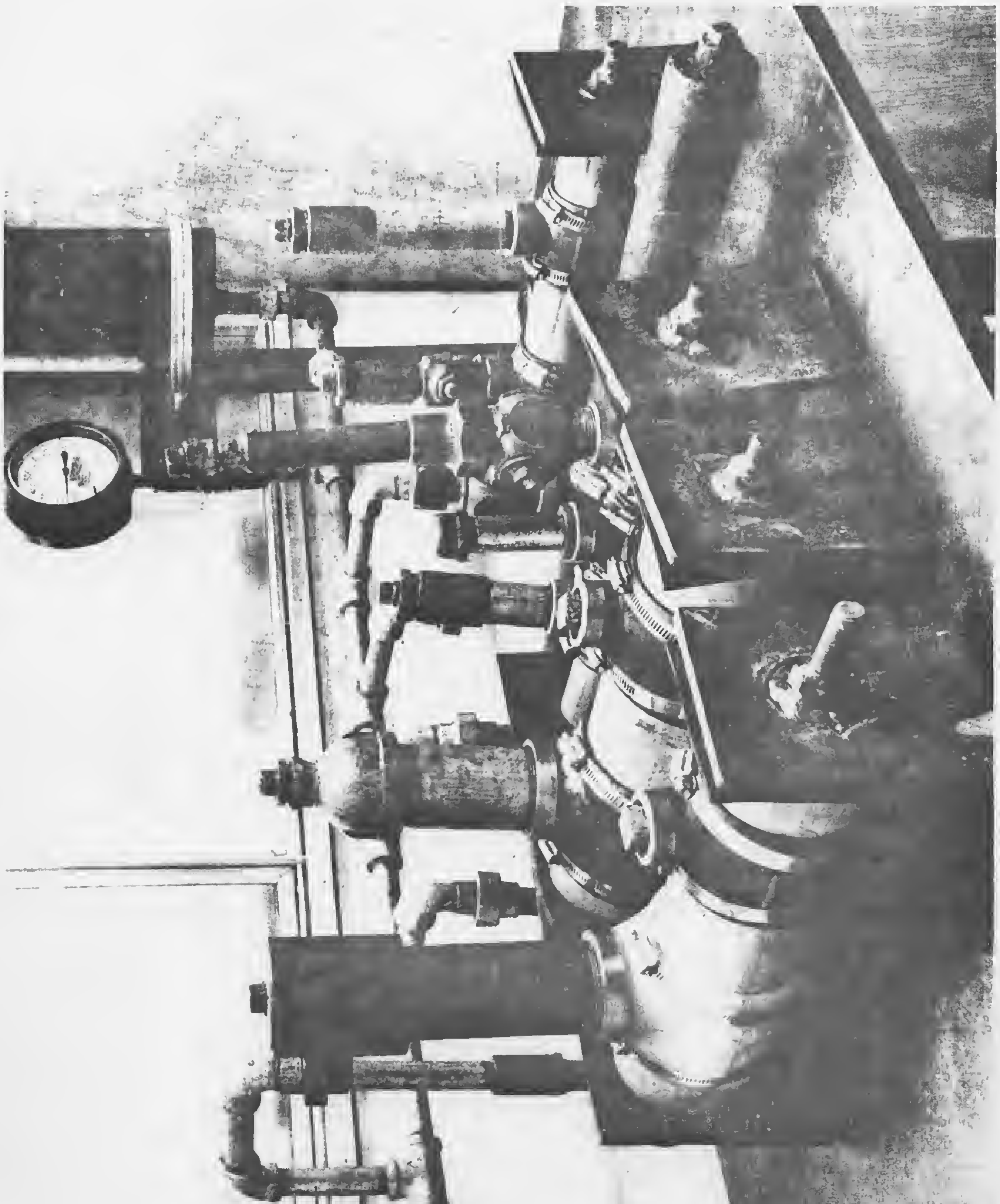


EXHIBIT 7 TESTING RIG

PROJECT NO. 184-1001

Various Tests and Evaluation of 2 x 1 Molded Saddle (Used approximately 25 samples)

Low temp test:

5° below zero 12 hours - no noticeable strain at normal impact or drop repeated impact full jump on body - no fracture or breaks - signs of elongation and strain only.

Boss shrinkage 70° ± to -5° ±.= .006"

Approximately 1/2 to 1 thread turn tighter at freeze

High temp test:

2 hours @ 150°   1 hour @ 250°

1/2 thread turn looser at 150°

Boss expanded 70° ± to 150° .008"
Boss expanded 70° ± to 250° .014"

1" I.P. - 1" nipple torqued to 60 ft.lb.

Bottomed out at 45 ft. lb. Strain at boss juncture started at 45 ft. lb.

1" I.P. short vibration and impact test

12" long nipple in place (room temp), repeated movement of nipple, hammering on nipple shows strain mark around boss juncture

1" Plastic threaded nipple fit ~~tests~~ thds. good

Steel nipples gaged at 1/2" average)   Thread fit okay but
Steel nipples tight at 3/4" average)   should not be any looser

Test 13

1" CC with cap room temp 70

2.38 cyl. 1-1/8 hole down through 1" bronze corporation stop, dry threads

Bow at center of joint 1/32 increasing to 3/64 at 160, 1/16 at 320

Boss diameter at)   +.003 diameter @ 250 psi
lowest point   )   +.007 diameter @ 400 psi

Leaked at gasket 400 psi

EXHIBIT 8   A SPECIMEN TEST REPORT

Test 13 (Cont'd)

contd

Centered to 640 psi - band and threads held.

Bands torqued to 48 in.lb. (Breeze) when dropped from 400 psi lost 12 in. lb. torque.

Test 14

1" OC with cap room temp. 70

2.38 cyl. 1-1/8 hole down through 1" Breeze corporation stop, dry threads

Bowing at joint center when under pressure 50 lb. up

Torqued bands to 48 in. lb. (Breeze)

Drop from 100 psi lost 6 in. lb. torque

Drop from 160 psi lost 3" to 6 in. lb. torque

At 400 psi boss juncture began to yield

At 510 psi leakage occurred at threads and gasket

Blew gasket at 700 psi

Threads and band held at 700 psi'

Sign of plastic yielding at inner edge of bands on side gasket blew

Test 15

1" I.P. with cap room temp. 70°

54 in.lb. torque on bands (Breeze) 1-1/8 hole, down through 1" steel nipples, dry threads

560 psi leaked , started at thread

640 psi leaked at gasket

Stress marks at boss juncture started at 250 psi

Test 16

1" I.P. with cap - temp. 70°

54 in.lb. torque on bands (Breeze)

610 psi leak started at threads

650 psi leak started at gasket

Boss juncture started to yield at 330 psi

In tests 13 through 16 boss began to yield between 250 and 330 psi, always starting at high side of pipe then working around and down. This yielding was due to hydrostatic press alone lifting boss away from pipe. Must allow for yielding resulting from vibration and leverage, in addition to hydro-loading.

Test 17

1" I.P. with cap - Proto-type model in accordance with drawing

Threads dry - 1" steel nipple

Tested to 640 psi. No leak at gasket

Slight leak at threads starting at 400 psi (machined thread)

No indication of material yielding

Flexure Test dry

Cylinder mounted in vise. Steel nipple in fitting. Fitting tight on cylinder.

Scale attached 11" up from boss juncture

50 lb. pull resulted average deflection 1/2" (2¼°)

2 x 1 molded saddle showed strain marks at juncture of boss (Test #43)

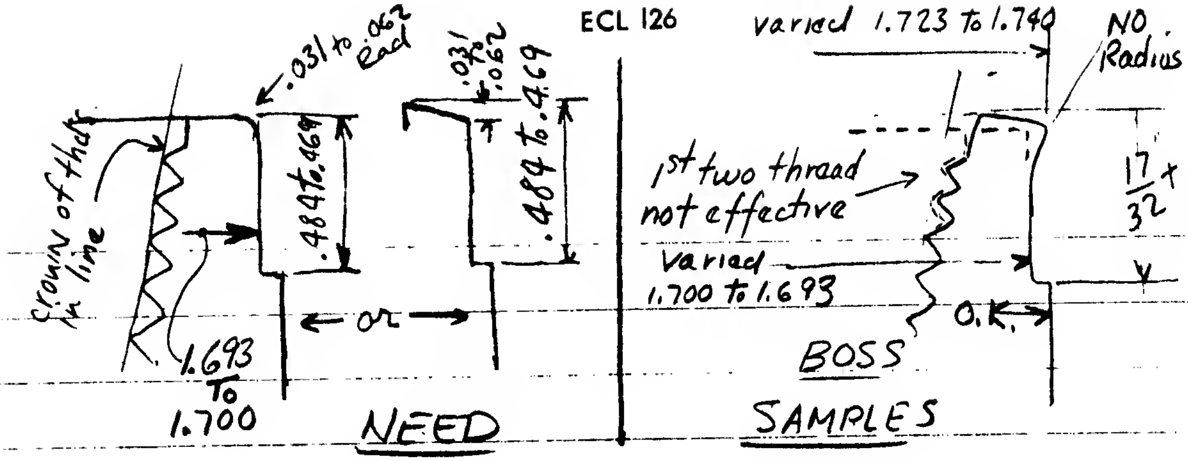
2 x 1 proto-type, no strain marks

2 x 1 PVC, no strain marks

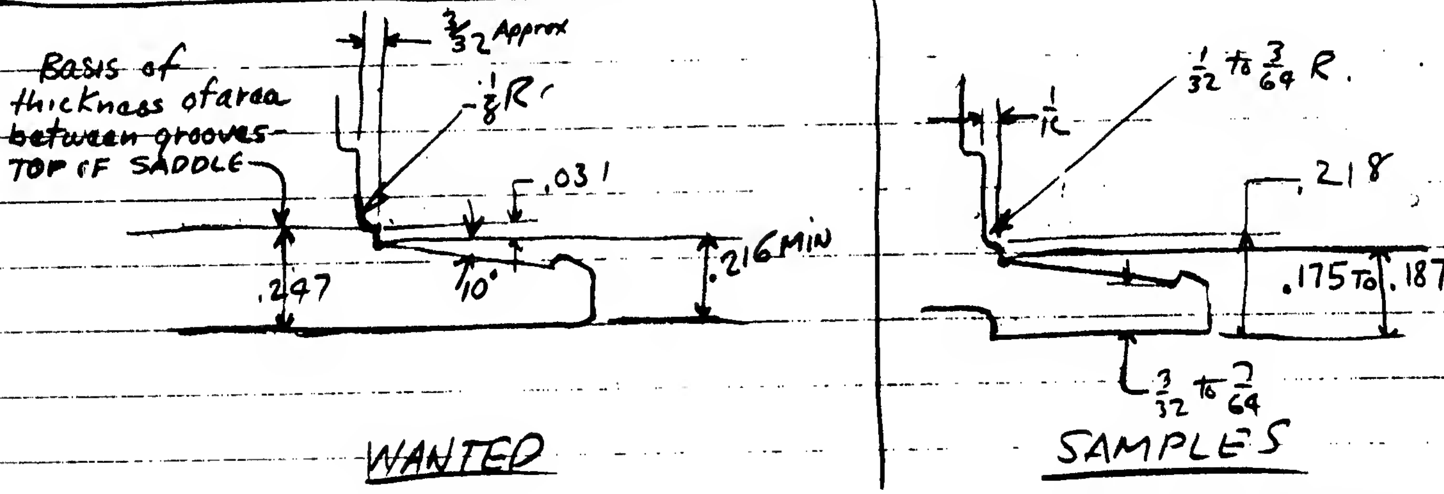
Frank E. Turner
4/10/67

EXHIBIT 8

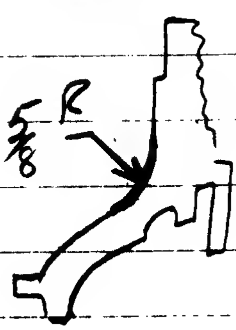
ECL 126

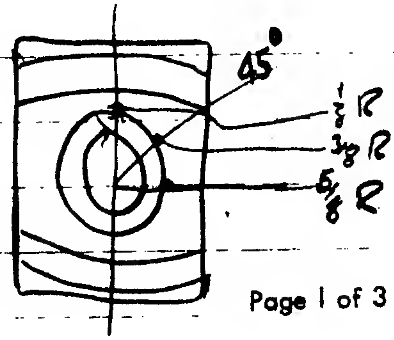


1. Correct top of boss to make to 2 or 3 threads usefull.
2. Shorten depth of shoulder to eliminate void when metal cap installed.
3. Provide corner radius or other means of clearing inside Radius of metal cap.
4. Correct dia. at top of boss
5. Thd can not [illegible]



1. Main thickness of body .029 to .041" too Thin (Both Top & Bottom Piece Important on Top Piece Not important on Bott Piece)
2. larger corner radius



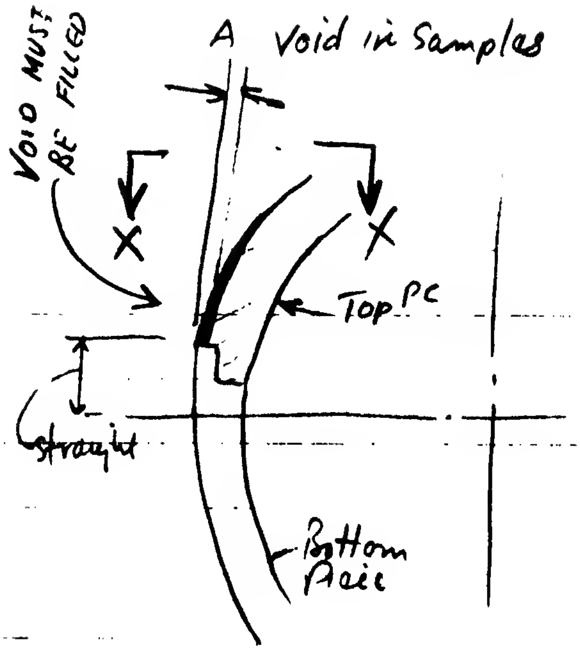


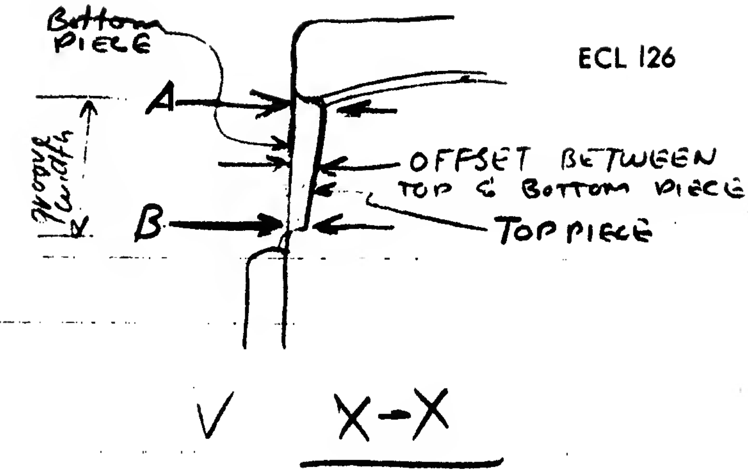
Increase corner radius
blend from $\frac{1}{8}$ R to $\frac{5}{8}$ R

EXHIBIT 9
LIST OF PROPOSED MODIFICATIONS IN THE PROTOTYPE MOLD

4-5-67 Turner

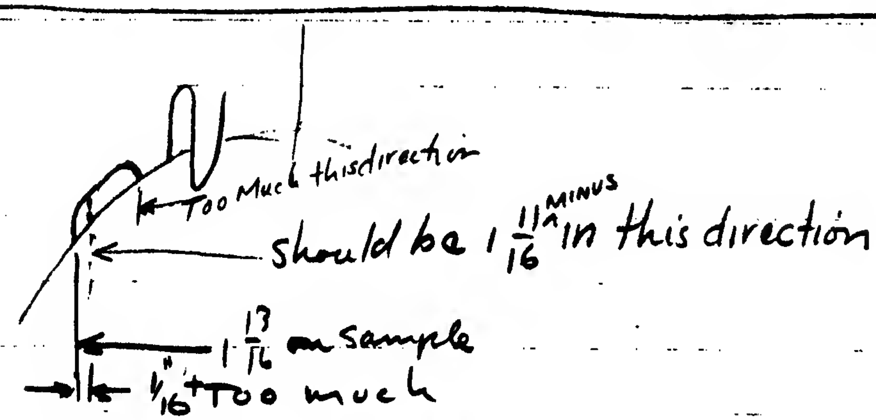
ECL 126

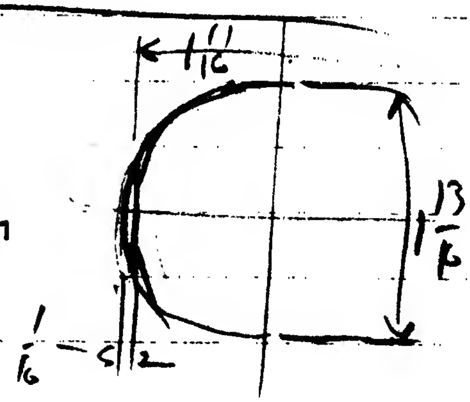




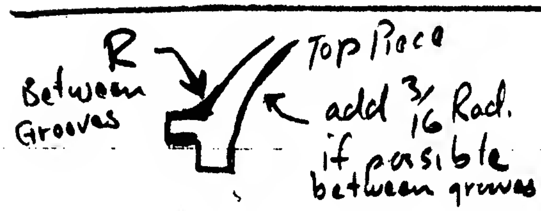
Joint at Groove

1. dimension A & B should be same, – as presently molded "A" is greater than "B" resulting in unbalanced band tension - changes circumference at A & B.
2. Bottom of groove in top piece should be blended to match groove in bottom piece





1. Correct gasket opening

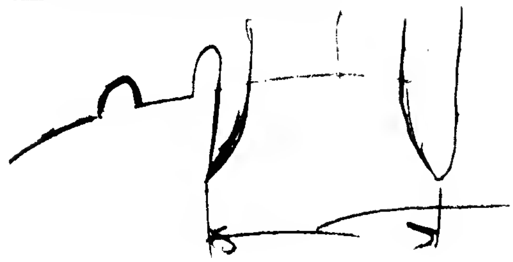


add Engraving + match mark

EXHIBIT 9

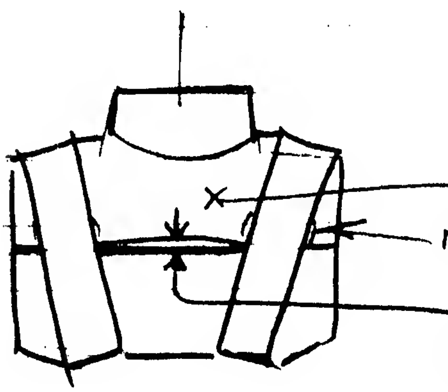
4-5-67 Truman

Questions



can this out of roundness be controled - This direction
other direction is O.K.

Weak - all around, at juncture of Boss and Body

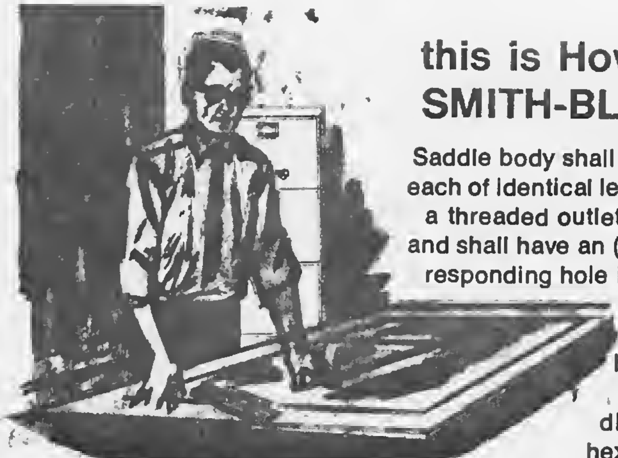


Too Thin across this area.
Pressure lost here due void under strap.
Joint opens up under normal hydrostatic pressure

Control of discoloration when over stressing

EXHIBIT 9

4-5-67 [illegible]



ECL 126

this is How to Specify the . . .
SMITH-BLAIR, INC. 342 SADDLE

Saddle body shall be of molded polypropylene and shall consist of two halves, each of identical length, fully encircling and supporting pipe. One half shall have a threaded outlet boss reinforced with a stainless steel flanged cylindrical cap and shall have an (optional) integral positioning neck which protrudes into a corresponding hole in pipe thus preventing saddle from rotating or shifting. An elastomeric O-ring seal of nitrile (NBR) shall be bonded into an annular groove of saddle body. The saddle body halves shall be clamped to the pipe with two all stainless steel worm drive clamps which shall fit into diagonally opposed grooves of saddle body. The stainless steel worm screws shall have slotted hex heads. The saddle design is to be such that metal portions of saddle are not in contact with outside surface of pipe.

31 SADDLE COMBINATIONS OF PIPE RUN AND OUTLET SIZES ARE OFFERED WITH 8 BASIC SADDLES AND 5 BUSHINGS...

NOMINAL PIPE SIZE x TAP SIZE	BASIC 342 SADDLE — NOMINAL DIMENSIONS						
	A	B	C	D	E ORIFICE		
	PIPE O.D.	END TO END	CENTER TO END	HOLE DIA. IN PIPE	DIA.	AREA SQ. IN.	TAP THREAD SIZE
1"x¾"	1.315	3⅛"	1 11/16"	⅞"	¾"	.442	¾" I.P.S.
1½"x1"	1.900	3⅜"	2⅛"	1⅛"	1"	.785	1" I.P.S. or C.C.
2"x1"	2.375	3⅜"	2⅜"	1⅛"	1"	.785	1" I.P.S. or C.C.
2½"x1"	2.875	3⅜"	2⅝"	1⅛"	1"	.785	1" I.P.S. or C.C.
3"x1"	3.500	3⅜"	2 15/16"	1⅛"	1"	.785	1" I.P.S. or C.C.
3"x2"	3.500	4½"	3"	2⅛"	1 31/32"	3.045	2" I.P.S.
4"x1"	4.500	3⅜"	3 7/16"	1⅛"	1"	.785	1" I.P.S. or C.C.
4"x2"	4.500	4½"	3½"	2⅛"	1 31/32"	3.045	2" I.P.S.

SMITH-BLAIR, INC. TYPE 303 NYLON REDUCING BUSHINGS

I.P.S. THREAD

2" x 1½"
1" x ¾"
1" x ½"
¾" x ½"

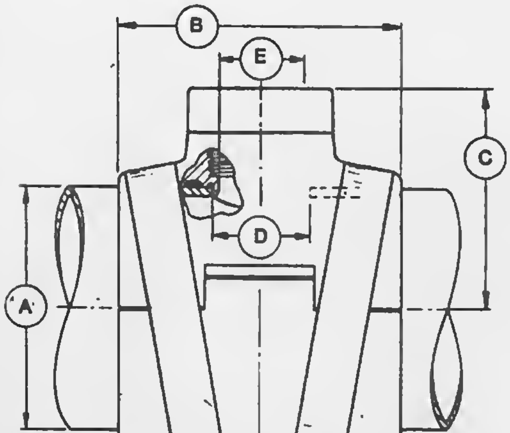
C.C. THREAD

1" x ¾"

SADDLES WITH C.C. (AWWA) THREADS ARE FURNISHED WITHOUT THE POSITIONING NECK.
SADDLES WITH I.P.S. THREADS ARE FURNISHED WITH OR WITHOUT THE POSITIONING NECK.

NOTE: For price information see Bulletin No. 340-01

DISTRIBUTED BY



PATENT PENDING

EXHIBIT 10 LIST OF AVAILABLE SADDLE SIZES

Main Office and Factory:
535 Railroad Ave. (P.O. Box 2047)
South San Francisco, California 94080
Phone: 761-2352; 583-3224 (Area Code 415)

Southwest Office & Factory:
300 Waco Street (P.O. Box 1927)
Texarkana, Texas 75501
Phone: 838-6516 (Area Code 214)

SMITH BLAIR INC. ®

SERVICE CENTERS

5635 E. Imperial Hwy.
South Gate, Calif. 90280
Phone: 773-4047 (Area Code 213)

West Newton Rd. (P.O. Box 927)
Greensburg, Pa. 15601
Phone: 834-8370 (Area Code 412)

1952 Milwaukee Way
Tacoma, Wash. 98421
Phone: 383-4668 (Area Code 206)

BULLETIN NO. 342-01

342 PLASTIC SADDLE

Requirements As To Quality

a. Flash (Fin) either or both sides. Located at mold parting lines. Thin flashing along this line projecting not more than 1/32" is acceptable.

b. Flash (Fin) around top of boss, either partial or all around. Flash in this area can prevent proper assembly of metal re-inforcing cap, therefore not acceptable.

c. Flash (Fin) around top of positioning neck opening. Flash in this area can affect hydraulic capacity of saddle and may cause customer concern, Flash projecting not more than 1/64" is acceptable.

d. Damage to bottom edge of positioning neck. When saddle is ejected from mold it is placed on a cooling fixture with same contour as pipe. It is slotted to clear positioning neck. Occasionally, when saddle is being placed on fixture (saddle still warm), the neck is not aligned with slot and results in bending and distorting edge of neck. If excessive (not allowing neck to enter the required specified hole size in pipe) it will not be acceptable (unless we elect to keep aside for filling orders where, neck is to be removed).

e. Neck has slight tendency to warp outwardly in this direction and cause out-of-roundness. This is acceptable as long as neck will enter the required specified hole size in pipe.

f. Saddle body top has tendency to warp inwardly at bottom when cooling. If dimension f. decreases more than 1/16", it is not acceptable.

g. Saddle body bottom is designed to snap onto pipe by having dimension (g.) slightly less than the pipe diameter. Not acceptable if it drops off from bottom side of specified plastic pipe.

h. Same as (a.)

i. Gate. The plastic runner is broken off at this point (one side of body only). Breaking off results in slight dis-coloration at break. This is acceptable.

j. Nicks and numerous scratchings on saddle body mostly around base of boss. These are due to nicks in mold, which are a result of not carefully replacing thread insert into mold after each cycle. This is not acceptable.

k. White line type mark at junction of bose and saddle body. This discoloration is caused by elongating and rearranging the molecular structure of the material. Occasionally this may occur when saddle is on cooling fixture and thread in-sert is being unscrewed. This is not acceptable.

l. Warpage, (teeter-totter). This may be caused when the warm saddle is on cooling fixture and the insert is being un-screwed. Acceptable if dimension (l.) is less than 1/32".

342 Plastic Saddle
Requirements as to Quality

m. Part incomplete - mold was not fully filled. Usually on side of body opposite the gate. Top or bottom body piece. This is not acceptable.

n. Void in threads. On side of base opposite the gate, where the plastic material feeds thru mold under high pressure, welds itself together. Lack of pressure in molding causes this. This is not acceptable.

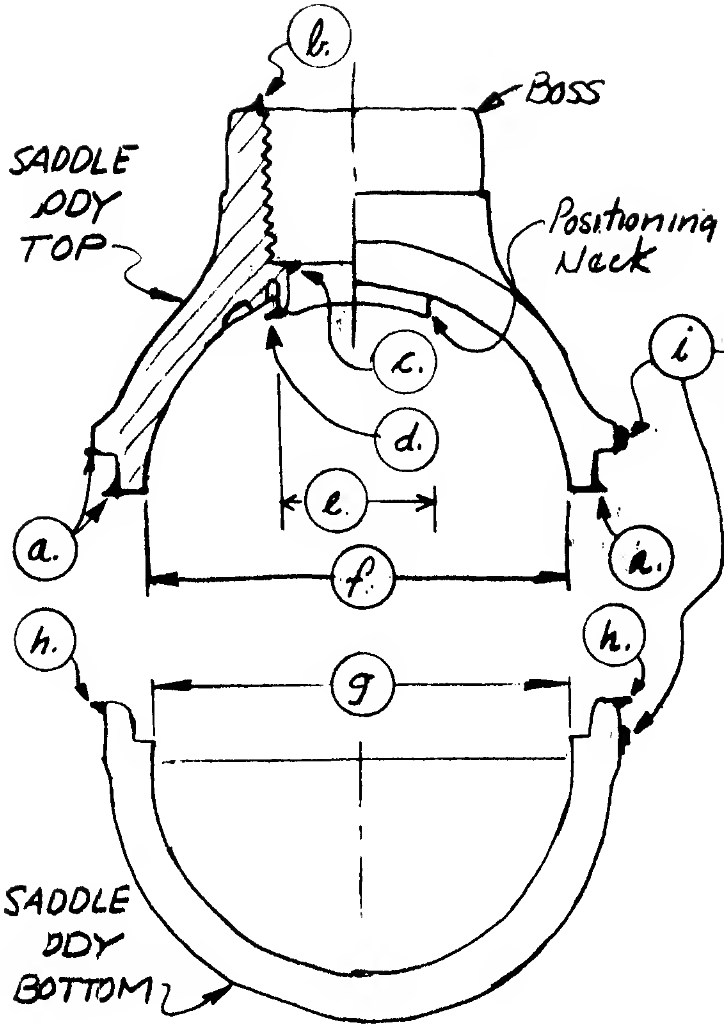
GENERAL

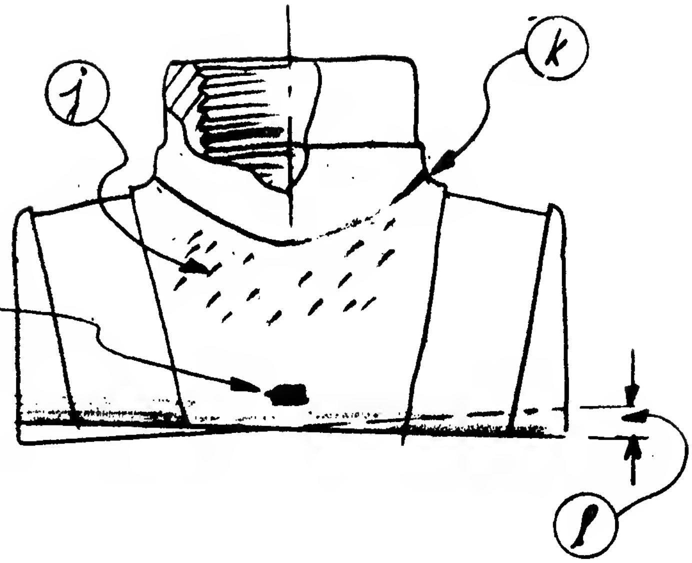
Flashing is caused by excess pressure in mold. Sometimes it is necessary to increase the mold pressure in order to avoid sinking (cavitation) in the heavier wall sections of saddle. This must be taken into consideration when evaluating quality.

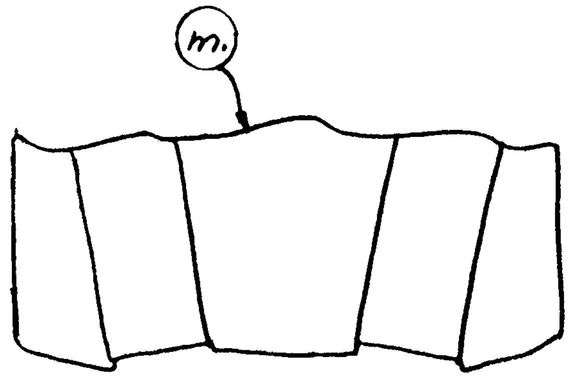
The saddle bodies normally will be received from supplier with the tops and bottoms in separate containers. The The molders usually make their count by weight, and should not be off count more than one or two in 500. They usually run about 5% extra in order to supplement rejects or misruns, thus avoiding costly set-up charge. Do not re-order in quantities of less than 5,000 if possible, in order to avoid excess part cost.

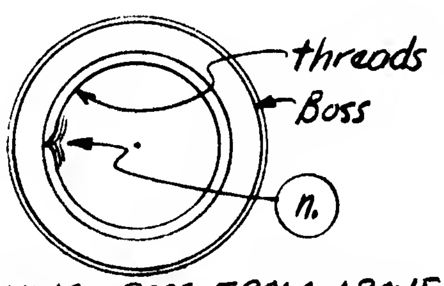
Frank E. Turner
July 14, 1967

EXHIBIT 11









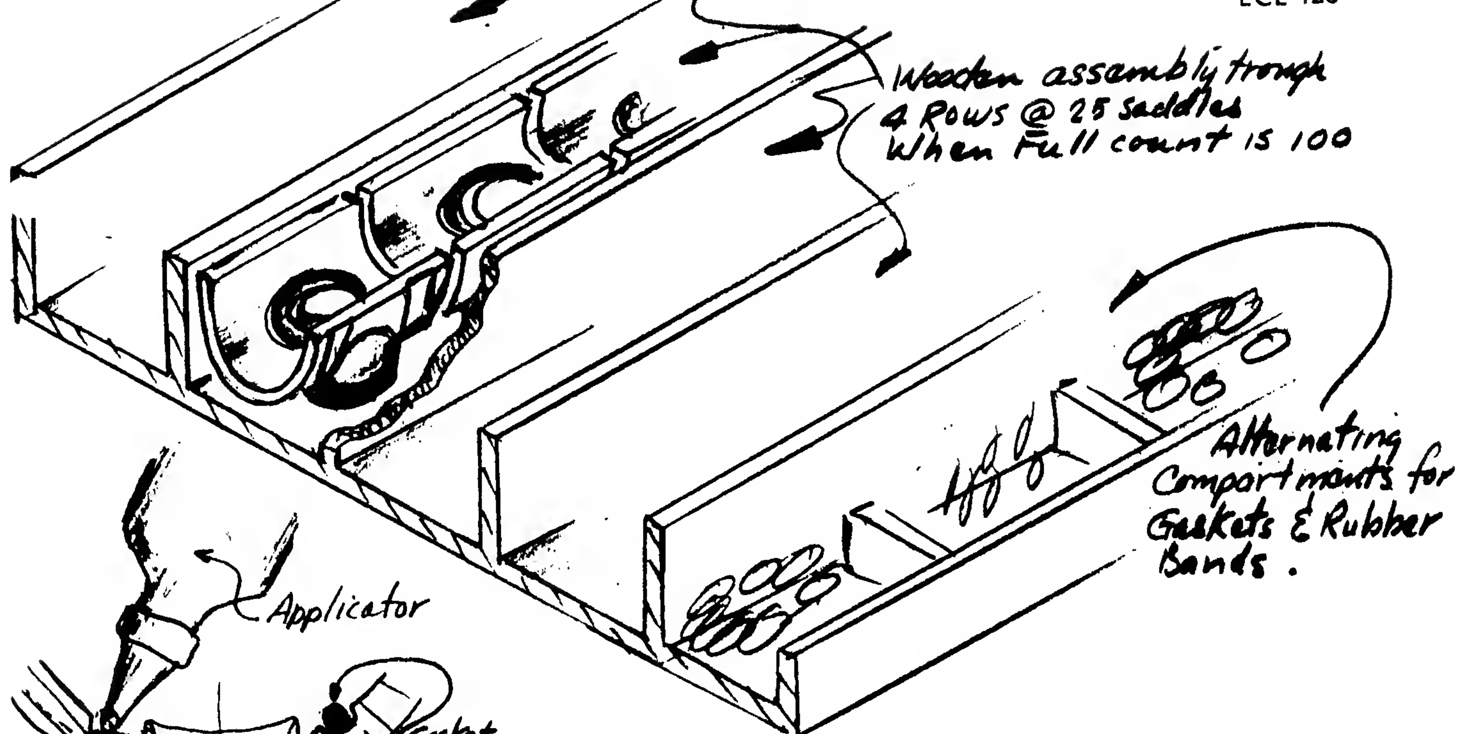
VIEWING BOSS FROM ABOVE

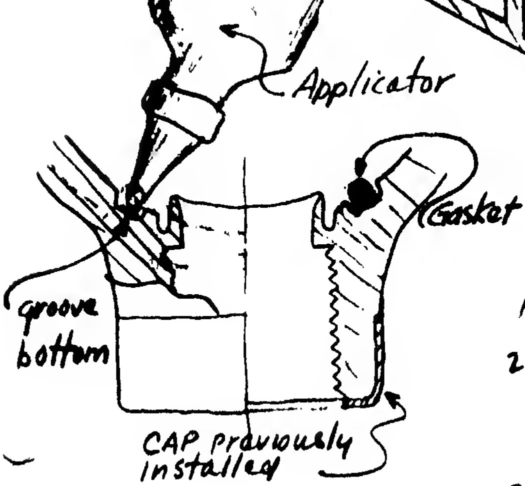
EXHIBIT 11

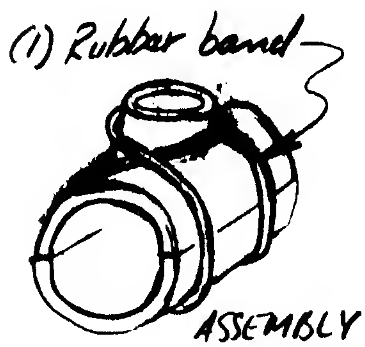
342 PLASTIC SADDLE

QUALITY

7-14-67 FT







STEPS

1. Fill trough with saddles - Boss down as shown.
2. Apply thin (abt. 5mil) even coat of adhesive to full width in groove bottom of all saddles in trough. work one row at a time from left to right.
3. Do not apply adhesive to gasket.
4. When all saddles in trough (100) have been coated - proceed to install gaskets in grooves in the same order as grooves were coated. This should allow sufficient time for adhesive to become tacky (depending on room temperature, etc.).
5. Place accuratly in groove and press lightly.
6. After installing to all saddles in trough re examine all to be sure gaskets have remained in contact.
7. Prior to removing saddle tops from trough - place a saddle bottom on each.
8. When all saddle Bottoms in place - install rubber band, thus holding the two halves together for shipment and/or storage. This also protects gasket from being Knocked out of groove.

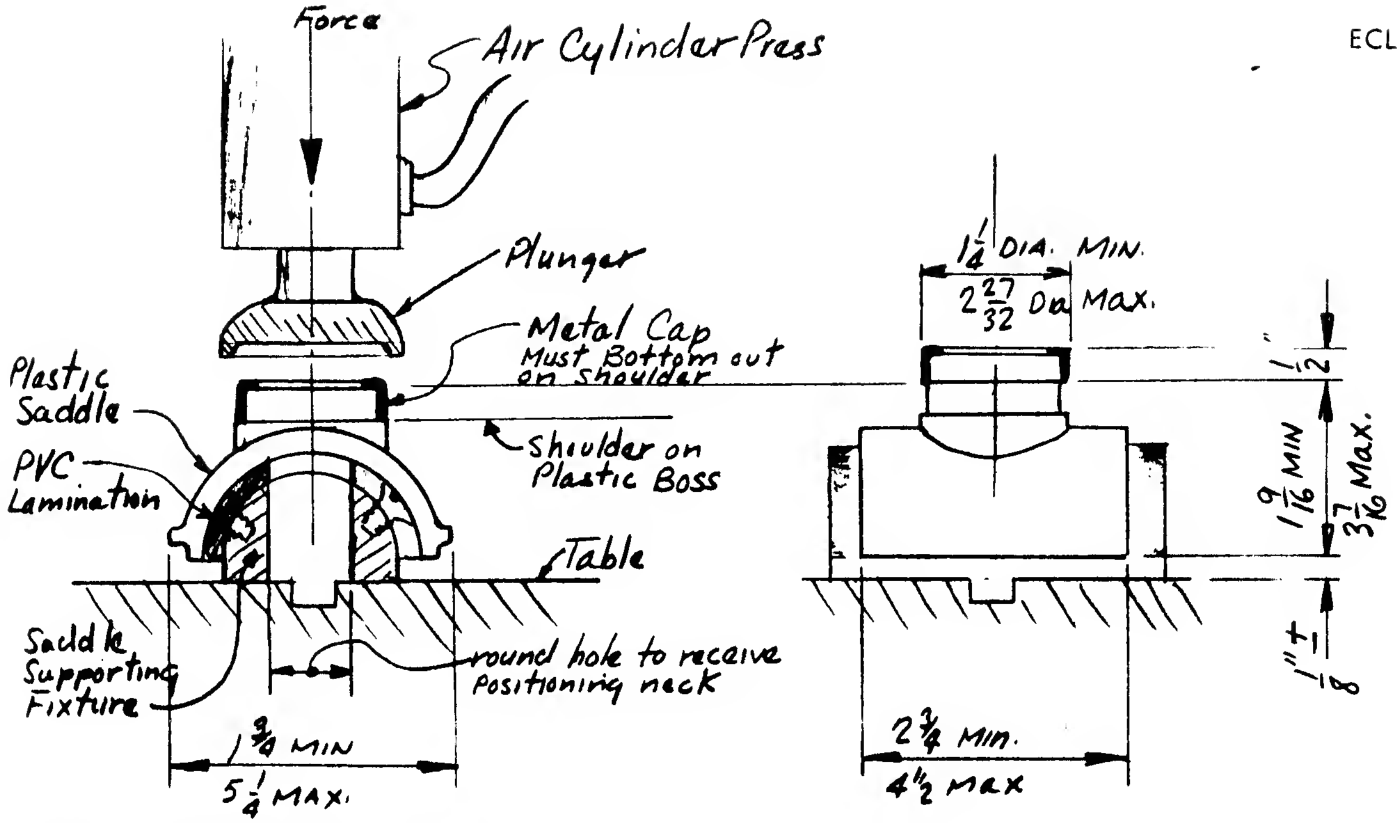
NOTE

- Recommend use of Plastic Applicator Bottle with long nose and approx. 1/64" dia orifice - Keep nose clean with TOLUOL.
- Cleaner: TOLUOL (PURIFIED TOLUENE)
- ives must be clean before applying adhesive - air clean when trough Full.

Estimated production time req'd
Steps 1 to 8 incl.
.25 min. max per saddle

342 PLASTIC SADDLE GASKET & BODY ASSEMBLY

EXHIBIT 12 ASSEMBLING INSTRUCTIONS 7-12-67 F.T.



Recommended Fixture for capping

- Air operated press – bench mounted – foot controled
- Force required to press on cap estmated between 100 and 750 Lbs.
- Plunger to be of size & handle min. & max. cap diameters
- Supporting fixture is to fully support saddle body. It should have a 180° section of Plastic Pipe attached To facilitate wear and To avoid scratching of saddle body. It is to have std. hole size to receive saddle positioning neck. If neck is faulty it will not enter hole, in this case set aside and reclassify
- Cap is to bottom out on shoulder of boss – all around. Excessive flashing on boss can prevent this, therefore examine boss prior to capping
- The Capping fixture assembly should provide allowance for handling saddle sizes 1" thru 4", Clearance wise, stroke wise, etc.
- Do not apply more pressure than is actually needed to properly seat cap.

Caps

- Occasionly misrun caps will be mixed in with the good ones – discard these
- Caps are received in the condition they come out of the press with a light film of oil. This film of oil is to be removed by batch dipping in a degreasing solution.

Estimated Prod. time
0.12 minutes per saddle max.

342 PLASTIC SADDLES 1" thru 4" run & 1/2" thru 2" Boss
REINFORCING CAP ASSEMBLY

7-12-67 FT.

New Product Development Dept.
March 13, 1968

PROCUREMENT OF 342 PLASTIC SADDLE COMPONENTS AND ACCESSORIES

SADDLE BODY

Vendor: Jupiter Engineering, Inc.
1165 O'Brien Drive
Menlo Park, California 94025

Telephone 323-7724
Contact: Mr. Dave Leidholm

Saddle Body consists of a top piece and a bottom piece. This represents one set.

For the eight basic saddles there are four mold bases. Each mold base has two sets of saddle cavities as follows:

Mold Base No. 1

2 x 1 and 1½ x 1 cavities

Mold Base No. 2

3 x 1 and 4 x 1 cavities

Mold Base No. 3

2½ x 1 and 1 x 3/4 cavities

Mold Base No. 4

3 x 2 and 4 x 2 cavities

Saddles can be run in combination as indicated above or with one-half the mold shut off and one size only run. For the best part cost run two sets of saddles (2 cavity sets) at a time when possible. Minimum order for any one size is to be 1,000 sets. The saddle body part cost is as follows: (Based on running one or two cavity sets at a time.)

Size	1 cavity set	2 cavity set
1 x 3/4		
1½ x 1		
2 x 1		
2½ x 1		
3 x 1		
3 x 2		
4 x 1		
4 x 2		

The molded C.C. thread is available on the 2 x 1 size only.

Jupiter is to install reinforcing caps onto saddle boss at the rate of   per saddle. For this we must have the necessary amount of caps at Jupiter when (or before) the molding is being done.

Purchase Order to Jupiter should indicate what portion of Saddles on order are to be with I.P. caps and what portion with C.C. caps.

Saddle Material:
Shell Polypropylene V-526, Shell Chemical Co.
Color-A4B47D Blue 3.0 gm./1# Shell Polypro.

Orders for saddles should be placed with Jupiter as far in advance as possible in order for placement into their schedule, and in order for them to have the raw material (resin and coloring) on hand.

Lead time required estimated as two to three weeks or more. Purchase Order should indicate Part Numbers concerned.

BOSS REINFORCING CAPS

Vendor: W & W Tool & Die Manufacturing Co.
1322 Marsten Road
Burlingame, California 94010

Telephone: 342-2900
Contact: Mr. Frank Walch

Cap Material: Stainless steel Type 302/304
Caps available for 2" I.P., 1" C.C., 1" I.P., 3/4" I.P. and 3/4" C.C. tape.

The part cost is as follows:

Size	Part No.	5,000	10,000	20,000	50,0000
2" I.P.	170032				
1" C.C. 1" I.P.	170029 170028				
3/4"C.C. 3/4"I.P.	170027 170026				

The cost includes the material and labor by W & W.

When caps received from W & W they are to be thoroughly degreased. Use Inhibisol or equal.

After caps degreased, ship to Jupiter for installation on saddle body.

Minimum for one size, 10,000 when possible, since material is ordered from mill in strip form.

Order should be placed with W & W as far in advance as possible. Material from mill takes approximately three to five weeks.

Lead time required estimated seven to eight weeks.

Purchase Order should indicate part numbers concerned.

Recommend maintaining an extra supply of these components (caps). They have been the bottle-neck item during the first six months of saddle production.

O-RINGS

Vendor: Nor-Cal Seal Company
840 Doolittle Drive
San Leandro, California

Telephone: 569-3121
Contact: Don Raichle or Michael Fisher

Material: Nitrile (Buna N) (NBR)

O-Rings required for the eight basic saddles are as follows:

Saddle Boss Size	O-Ring Description	Cost Each - Quantity			
		5,000	10,000	20,000	25,000
2"	Parker 2-216 N525-6	$.0754	$.07085		$.06187
1"	Parker 2-222 N219-7	.0385	.0355	$.0328	
3/4"	Parker 2-333 N525-6	.0326			

Lead time required three to five weeks.

WORM DRIVE CLAMPS

Vendor: Breeze Corporation, Inc.
200 Liberty Avenue
Union, New Jersey 07083

Telephone: (201) 686-4000
Contact: Mr. G. L. Kirk or factory rep.
"Gene" Wohler Company
158 W. Pico Blvd.
Los Angeles, California
Telephone: (213) 746-1597
Contact: Gene Wohler

Material: Type 302 stainless steel throughout except
Type 305 stainless steel screw

Clamps required for the eight basic saddles are as follows:

Saddle Size	Clamps Type QS-200	Over 5,000	Blanket Order Over 100,000	Blanket Order Over 200,000
1	M24H			
1½	M32H			
2	M40H			
2½	M48H			
3	M60H			
4	M80H			

Clamps are presently ordered in a blanket order of 200,000 (P/N 18074). There is a bàlance of 119,800 clamps to be scheduled into this purchase order, prior to November 28, 1968, if possible, to take advantage of the larger discount.

Refer to P.O. 18074 for additional specification.

On purchase orders indicate "Material certification required."

Lead time required estimated five to seven weeks.

O-RING ADHESIVE

Vendor: H. B. Fuller Company
57 South Linden Avenue
South San Francisco, California 94080

Telephone: (415) 761-1763
Contact: Mr. Lester Brenno

Adhesive: Fuller No. SC-564-9

Purchase Order to indicate "Containers of this adhesive to bear statement - 'Food Packaging Adhesive'"

Maintain stock of one gallon minimum. Cost in two gallon lots is $5.95 per gallon.

Lead time required two to three weeks.

SADDLE TORQUE WRENCH

Vendor: Jo-Line Tools, Inc.
8442 Otis Street
South Gate, California 90280

Telephone: LO7-1366
Contact: Mr. Hank Thorn

Torque release 61-inch lbs. plus-minus 5%.

Current cost $11.40 less 33-1/3, less 15%
Cost increase due April, 1968 (est. $11.95)

Minimum order 240 wrenches (20 cases). Included with each wrench is one 4" x 6" x 1" box.

Lead time required five to six weeks.

BUSHING 1 x 3/4 C.C.

Vendor: Stoesser Tool & Die Company
2630 Fayette Drive
Mountain View, California 94040

Telephone: (415) 948-1417
Contact: Mr. Marvin Murphey

Material: Nylon Zytel 101
Color B1-05

Cost each based on order of 10,000 from a two cavity mold.

Lead time required estimated two to four weeks.

BUSHINGS I.P.

Vendor: Jupiter Engineering
(same as saddle bodies)

Material: Nylon Zytel 101
B1-05 Color

Mold consists of four cavities and is capable of molding (4) 1" x 3/4 I.P. Bushing at one time or (3) 1" x 3/4" I.P. plus (1) of either the 2 x 1¼ I.P., 1" x 1/2 I.P. or 3/4 x 1/2 I.P. at one time.

The cost each is as follows:

1" x 3/4" I.P.	1,000 to 10,000
2" x 1¼" I.P.	500 to 2,500
1" x 1/2" I.P.	500 to 2,500
3/4" x 1/2" I.P.	500 to 2,500

If ordered less than above quantities a $35.00 set-up charge will be made.

Lead time required estimated two to three weeks.

EXHIBIT 13

 1-25-68 N.P.D.

EVALUATION

ECL 126

COMPETITOR "X" Saddle
Size – 3 x 3/4
Matl. – Bronze
Mounted on JM Blue 160 PSI pipe
Top & Bottom pc secured by (2) 5/16"
Bronze slotted round head screws

(a.) Does not fully encompass pipe – approx 3/8" gap at each side

(b) As constructed, the top & bottom pcs act as a VISE. when screws are tightened the pipe is deformed inwardly in one direction and outwardly in the other direction – Pipe supports the saddle instead of the saddle reinforcing the pipe

(c) The ends of the saddle bodies tend to rotate inwardly when ears bend slightly in tightening the Screws – inducing undesirable stresses on pipe

(d) Saddle bottom pc. ears are threaded – requiring screws to be completly disassembled prior to assembly.

(e) Using only a single screw on each side of pipe, saddle will not draw to pipe evenly – unless on exact center resulting in unbalanced stressing of pipe.

(f) Edges of bodies in contact with pipe are rather sharp. and when saddle bodies are tightened on pipe the edges tend to dig or anchor in setting up a stress line in pipe and may worsen when pipe is subjected to expansion due to temperature or hydrostatic pressure

(g) It is possible, with a metal casting to have un-noticed metal scab(s) on inside surfaces or to have un-noticed warped bodies. which can direct undesirable stresses to pipe.

(h) When attaching a nipple or corp stop to the saddle - in order to properly tighten - a considerable amount of torque must be applied. To resist this torque (or turning force) the saddle body attempts to rotate on the pipe. The pipe must resist this by contact with the metal edges of saddle. The pipe surfaces at these points are sensitive. Notching, indentation or deformation can contribute to pipe failure at some later date

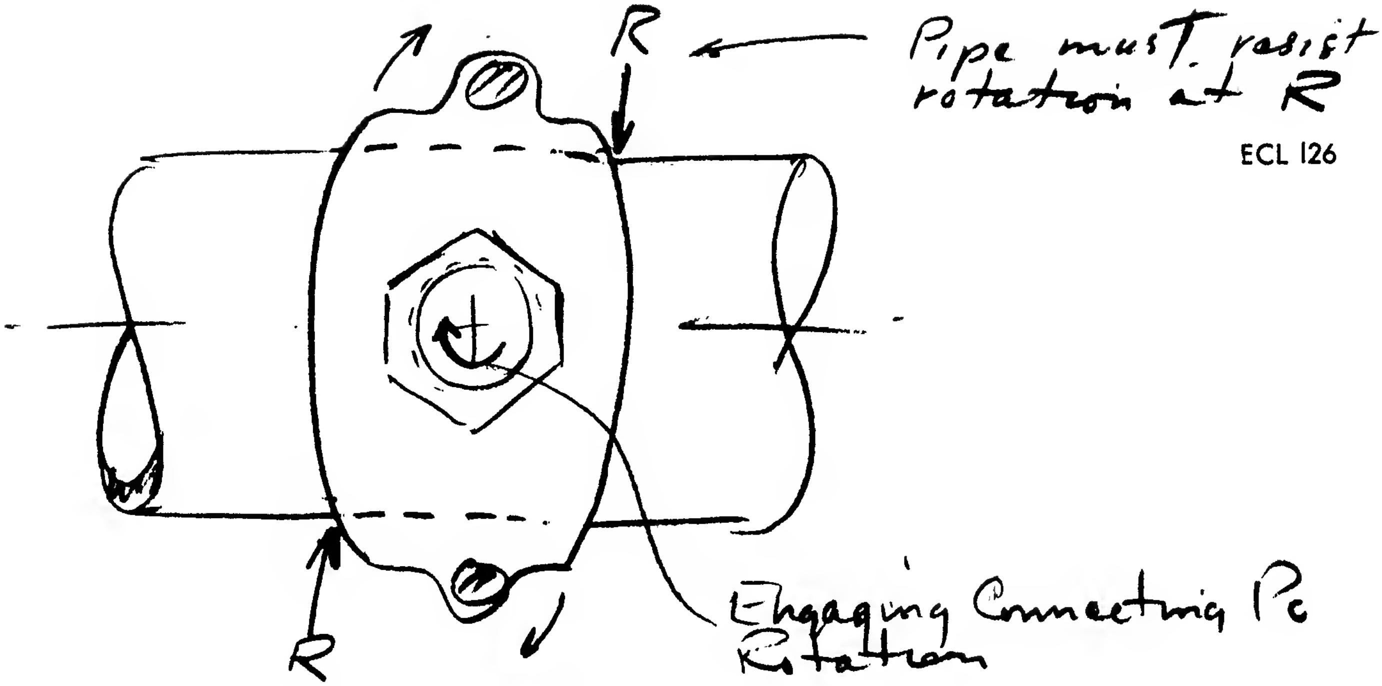
(i) Installation example: If installed tight onto plastic pipe on very warm afternoon (Pipe in expanded condition) say in an open trench. Then the next morning the temperature dropped 30 to 40 degrees and the pipe contracts (un-noticeable to eye). The trench is back filled. Installation considered complete. It is possible - That when the pipe contracted the saddle loosened slightly and possibly enough to cause leakage then or at a later date

(j) This saddle if used on thinner wall plastic pipe would worsen the previously mentioned conditions.

(k) also have heard that in some cases - that boss is not deep enough to receive corp stops - that the corp contacts to of pipe prior to being pipe.

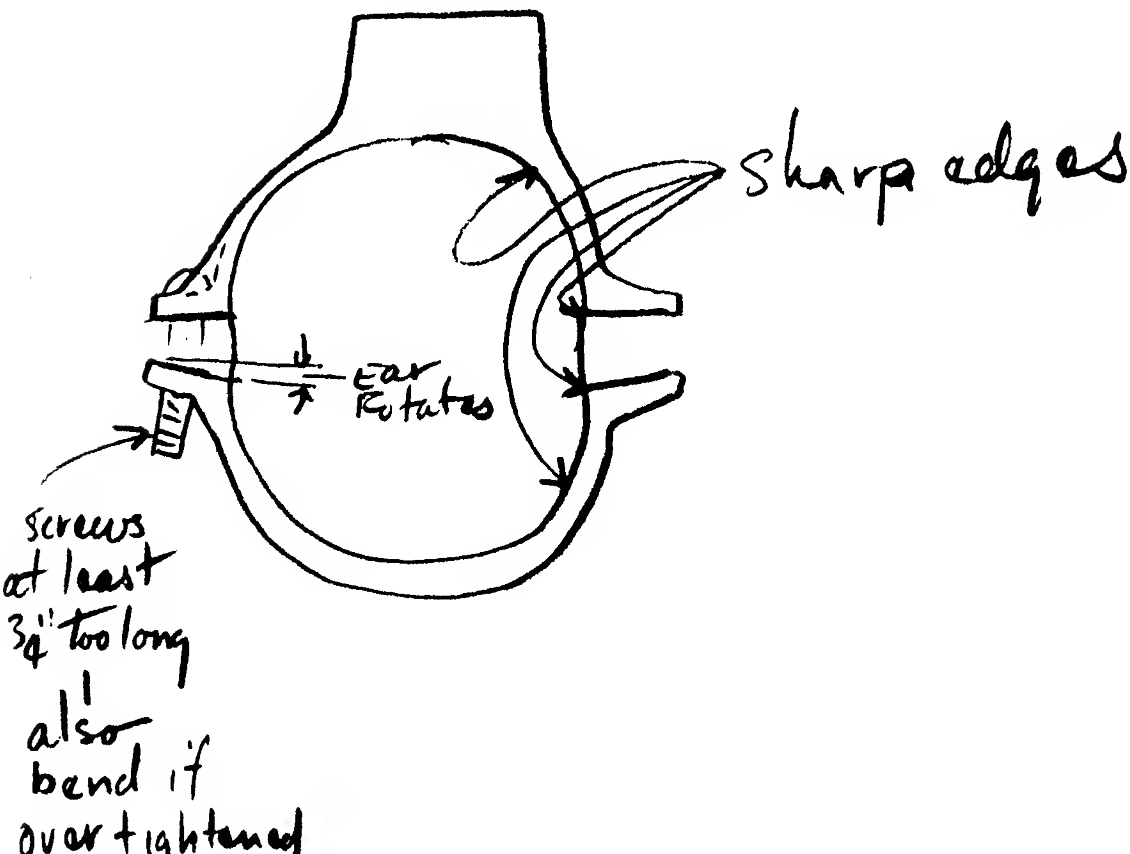
(l) Most of the aformentioned data applies to the COMPETITOR "Y" saddles also

EXHIBIT 14



R
Pipe must resist rotation at R
R
Engaging Connecting Pc Rotation

ECL 126



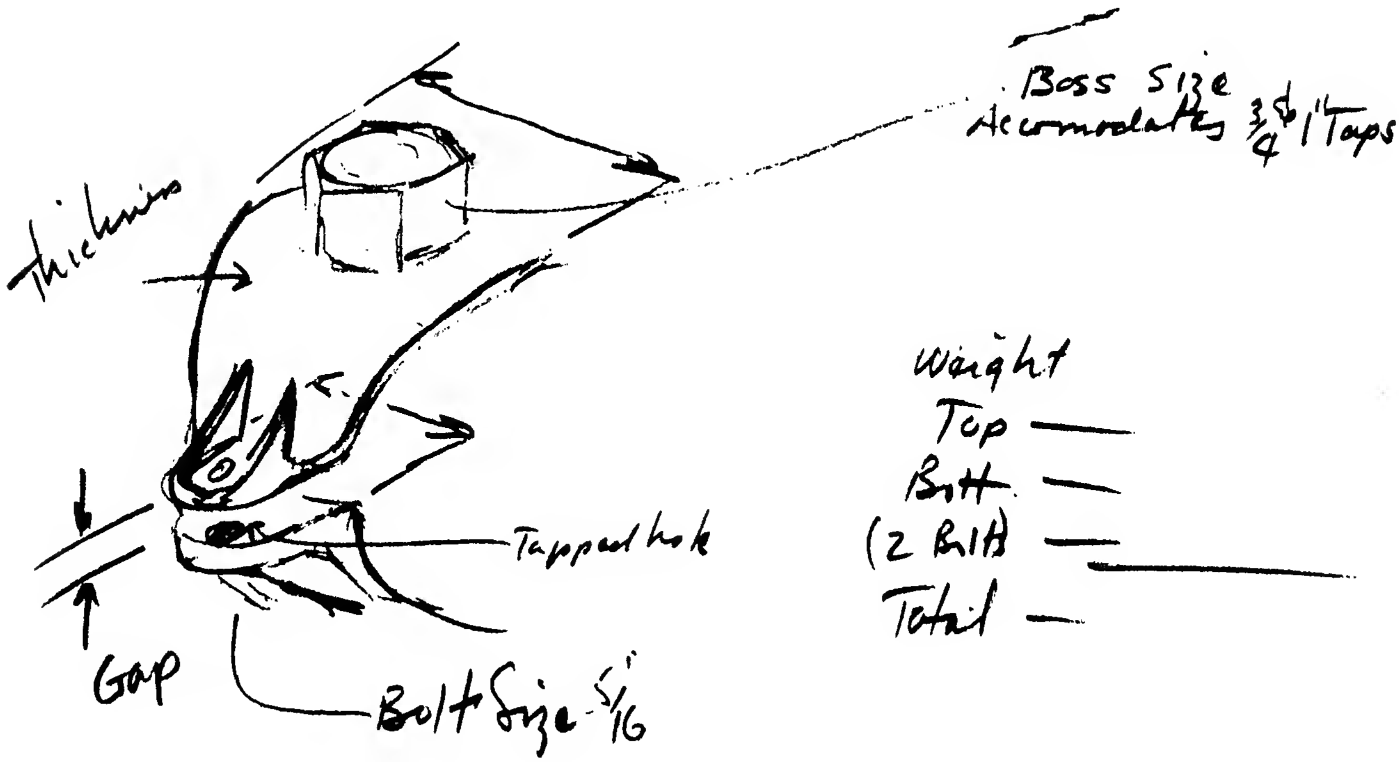
sharp edges
Ear Rotates
screws at least 3/4" too long
also bend if overtightened

Test 1-3-67

COMPETITOR "X" Saddle for Plastic Pipe

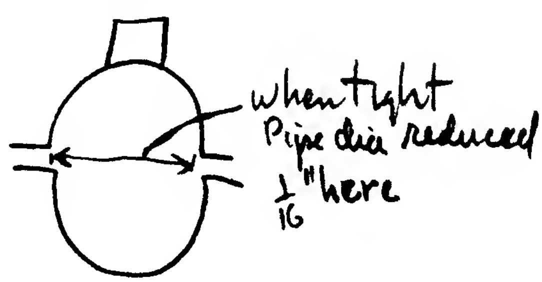
Test Cylinder JM 160 PSI Blue Plastic 3" Nom
OD 3.5000

Saddle description 3" x 3/4
All Cast Brass
Bronze Bolts (2) Rd. Hd. slotted



Weight
Top —
Bott —
(2 Bolts) —
Total —

Torked Bolts to 5#



Turner